Evaluation #2 Energy and rates February 25, 2014 P3 **Name:** Solution

1. List four different advantages associated with hydroelectric energy .

- Renewable
- No greenhouse gases produced / clean
- No fuel cost (lots of water available)
- ~~low cost~~
- Efficiency is high
- low operating cost

2. State Hess's Law. Explain how it can be applied to find the enthalpy change of a reaction.

The enthalpy change of a reaction is independent of the pathway the reaction takes but depends only on initial and final conditions.

ΔH can be determined using different methods
① ΔH_f° formation ② adding steps or series of Rxn

3. Write the equation for the formation of $Ni(CO)_4(g)$.

$$Ni_{(s)} + 4C_{(s)} + 2O_{2(g)} \rightarrow Ni(CO)_{4(g)}$$

4. *Use the following information to answer the next question.*

> Combustion of benzene is given by $C_6H_6 + \frac{15}{2}O_2 \rightarrow 6CO_2 + 3H_2O$ and standard enthalpy change of reaction is –3267.0 kJ. Standard enthalpies of formation of CO_2 and H_2O are –394 and –285.83 kJ/mol, respectively.

Calculate the enthalpy of formation of C_6H_6 (benzene) in kJ/mol.

$$\Delta H^\circ_{rxn} = 6\,\Delta H_f^\circ CO_2 + 3\,\Delta H_f^\circ H_2O - \Delta H_f^\circ C_6H_6$$

$$-3267.0\ kJ = 6(-394) + 3(-285.85) - x$$

$$x = (-2364 - 857.49) + 3267$$

$$x = -3221.49 + 3267$$

$$x = +45.51\ kJ/mol$$

$$\approx 46\ kJ/mol$$

5. *Use the following information to answer the next question.*

Consider the following reactions:

$2C_2H_4O(\ell) + 2H_2O \rightarrow 2C_2H_6O + O_2(g)$ $\Delta H = 715.6$ kJ (1)

$2CO_2(g) + 2H_2O(g) \rightarrow C_2H_4O(\ell) + \frac{5}{2}O_2(g)$ $\Delta H = 2042.2$ kJ (2)

Calculate the enthalpy change for the reaction:

$C_2H_6O(\ell) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(\ell)$

$\Delta H_1 \times (-\frac{1}{2}) + \Delta H_2(-1) = -2400$ kJ

	ΔH
Flip (1) and $(\times \frac{1}{2}) \Rightarrow$ $C_2H_6O + \frac{1}{2}O_2 \rightarrow C_2H_4O + H_2O$	-357.8
Flip (2) $\Rightarrow$ $C_2H_4O + \frac{5}{2}O_2 \rightarrow 2CO_2 + 2H_2O$	-2042.2
Add $\Rightarrow$ $C_2H_6O + 3O_2 \rightarrow 2CO_2 + 3H_2O$	$+2400$ kJ

6. Consider the chemical reaction below

$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g)$

Initially, 3.5 moles of O_2 are placed in a 4.0 L reaction chamber. After 3.0 minutes only 1.6 moles of O_2 remain.

a) Calculate the average rate of reaction with respect to O_2.

b) Calculate the rate at which H_2O is being formed.

a) $\frac{\Delta[O_2]}{\Delta t} = \frac{(3.5\ mol - 1.6\ mol)/4\ L}{-3\ min}$

≈ -0.158 mol/L.min

rate ≈ 0.16 mol/L.min

or 0.63 mol/min

or 0.011 mol/s

or 0.0027 $\frac{mol}{L.s}$

b) $\frac{\Delta[H_2O]}{\Delta t} = \frac{6}{5}\frac{\Delta[O_2]}{\Delta t}$

$= 1.2 \times 0.16$

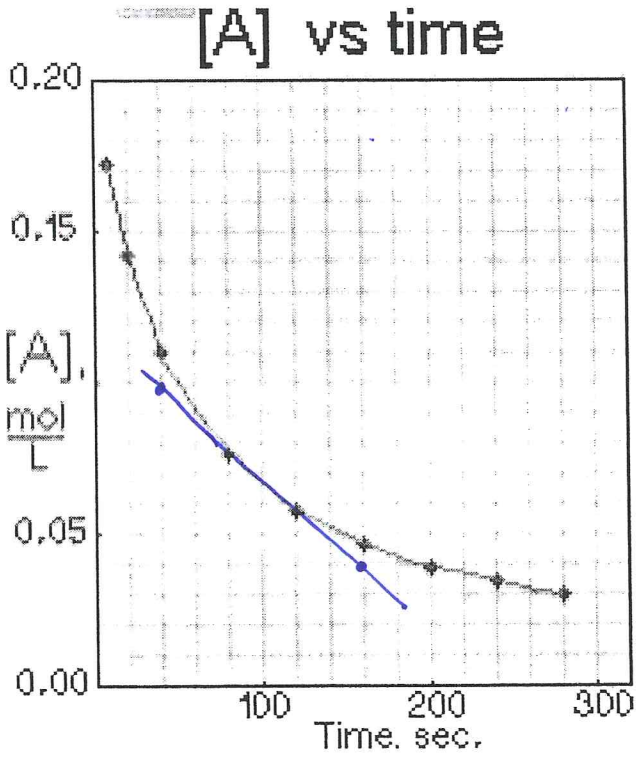
≈ 0.19 mol/L.min

7. The efficiency o heating water in a pot on a stove burner is 38%. How much heat must the burner release to raise the temperature of 2.75 kg of water in a pot on the stove from 20.5°C to the boiling point (100.°C)?

$$Q = 2750\,g \times 4.19\,J/g^{\circ}C \times (100 - 20.5)$$
$$= 916039\,J$$

$$Q = \frac{916039}{0.38}$$
$$\approx 2.4 \times 10^{6}\,J \quad \text{or} \quad 2.4 \times 10^{3}\,kJ$$

8. Find the instantaneous rate at 120 seconds.



slope of tangent at 120

$$\text{slope} = \frac{0.02 - 0.08}{220 - 40}$$
$$= -0.000333$$

instantaneous rate is $3 \times 10^{-4}\ \frac{mol}{L.s.}$